

1988/10. Significant structural relationships between some rock units associated with the Mt Read Volcanic Belt*

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SUMMARY

The contiguous Dundas and Dial Range troughs developed along a pre-existing Precambrian boundary, indicated by the distribution of remnants of the Rocky Cape region rock types present at the eastern margin of the troughs. Troughs developed by rifting, with movements at the margins recorded during early deposition. A more general deformation accompanied ultramafic emplacements originating within the rifted zones, with Mt Read volcanism occurring along the margin of the Tyennan region. No structures associated with an accretionary prism of an east-dipping subduction zone are present, and it appears that no subduction zone could have occurred within the troughs because of the correspondence, on opposite sides of the troughs, of rock types of the Rocky Cape region. Deformation associated with the final trough filling appears to be related to the movements of the Tyennan and Forth regions acting in continuity. The driving mechanism for rift development at a Precambrian crustal anisotropy, and for the eventual closure of the Eocambrian-Cambrian Dundas and Dial Range troughs, may be related to a possible westward-dipping Cambrian subduction zone at the present site of the postulated Tamar Fracture System.

ROCKY CAPE REGION REMNANTS

The Dundas and Dial Range troughs¹, which are associated with the Mt Read volcanic Belt, occur between comparatively unmetamorphosed Precambrian rocks of the Rocky Cape region to the west, and the metamorphic Precambrian rocks of the Tyennan and Forth regions to the east. Any tectonic model proposed for the development of these Eocambrian-Cambrian troughs must adequately account for the distribution of remnants of the Rocky Cape rock types which occur as inliers within and alongside the troughs. The remnants have been considered to be a valid indication of the existence of a pre-trough Precambrian boundary (Williams, 1976; Collins and Williams, 1986). Such remnants include the fault-bounded inlier of a correlate of the Oonah Formation of the Rocky Cape region at Concert Hill [372363]², which is on the eastern side of the ultramafic and associated rock types of the Dundas trough. Concert Hill appears to be rooted in Precambrian crust (e.g. Leaman, 1986), and there is no evidence that the ultramafic rocks have been transported from the east to their present position. Another remnant occurs

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1. For terminology see Williams (1976) and Structural Map of the Pre-Carboniferous Rocks of Tasmania, 1:500 000, 1976, Department of Mines, Tasmania. Also N.J. Turner, 1988.

2. Co-ordinates refer to 10 000 m Transverse Mercator Grid, Zone 7 (Australian Series).

at Mt Bischoff [375412], where the correlate of the rocks of the Rocky Cape region are surrounded by unfossiliferous sequences which include basaltic rocks.

Inliers of rock units showing similar metamorphic and tectonic histories to the metamorphic sequences of the Tyennan region can be traced from that region [e.g. 455425] to the Forth region at the north coast. There, metamorphosed Precambrian rocks are juxtaposed with a correlate of the Burnie Formation, which occurs in the Rocky Cape region some six kilometres to the west on the opposite side of the Dial Range trough. The Burnie Formation is at the western margin of the Forth region. In a limited area of exposure at Singleton Point [428444] the Burnie Formation is steeply thrust over the metamorphic rocks (Burns, 1965), but at Goat Island [427446] the outcrop is far more extensive and the boundary has been traced as a flat-lying thrust. Although no traces of material from the Dial Range trough are involved, the postulated flat-lying nature of the boundary may influence some into believing that the Burnie Formation correlate could have been thrust some six kilometres over the Eocambrian-Cambrian trough from the west to its present position. At Goat Island the boundary between the Burnie Formation correlate and the Precambrian metamorphics was determined as a flat-lying thrust by Burns (1965) mainly on the distribution of a breccia which he implied to be associated with it. The fragments are very angular and very closely packed, and are derived from the rock units the breccia rests on or is alongside. There is no mixing of breccia fragments of the Burnie Formation correlate with those from the Precambrian metamorphics, and movement within the zone appears to be negligible, which does not support gliding of an upper thrust plate of the Burnie Formation over the Dial Range trough. However, closer examination of the breccia indicates that it is probably unrelated to a thrust surface*, and omitting the breccia from consideration, the postulated flat-lying nature of a thrust disappears. At Goat Island the boundary between the Burnie Formation correlate and the metamorphosed Precambrian

* The breccia at Goat Island appears to include types of different origin:

(a) Fold core breccia, which forms a minor component.

(b) Largest component is of very angular fragments with all the structural features of cleavages, kink-bands etc. completely disoriented. The matrix is negligible and forms seams of deeply-weathered sand between the breccia fragments. There is no evidence of any abrasion of the fragments, and they appear to have accumulated in an open-cast environment for they may be stacked tightly into underlying angular cavities.

(c) The eastern area of the breccia is of disoriented blocks of metamorphosed conglomerate. The blocks are up to 5 m long and they occur in a zone alongside a box-folded area of the conglomerate rock-unit. A slight decrease in lateral confinement of such an area, as alongside a narrow and shallow gully, would cause release tension fracturing along axial surfaces of the folds, resulting in large blocks with a disorientation inherited from the box-folds.

Apart from the very small amount of breccia developed within fold cores, the breccia seems to have formed *in situ*, in an open-cast environment as a flat-lying deposit. The age of the breccia is later than all fold deformation, but earlier than that of an ironstone pan developed at the surface of the breccia in the east.

rocks appears to be of steep sheet faults, and there is nothing to support a contention that the Burnie Formation correlate glided over the Dial Range trough to its present position.

The distribution of the Burnie Formation and its correlates about the Dial Range trough indicates that this Eocambrian-Cambrian trough developed on and alongside an older Precambrian boundary. Similarly, the Dundas trough appears to have formed alongside an older boundary indicated by the distribution of the Oonah Formation and its correlates.

EARLY TROUGH MOVEMENTS

Early deposition within the Dundas trough was accompanied by movements at the trough margin. Brown (1980) found a zone of soft-sediment deformation indicating instability in the dominantly shallow-water Success Creek Group [367372], which are basal accumulations of the Dundas trough deposited on the Oonah Formation of the Rocky Cape region in the west. The soft-sediment deformation zone, which has been related to sub-aqueous landslides, consists of fragmented siltstone in a phacoidally cleaved mudstone (Brown, 1980). Obviously, to determine the development of the trough it will be important to establish the sense of movement within these zones, and suitable features for analysis are present such as strewn-out extensions of the siltstone fragments.

At Mt Bischoff [375412], Groves (1971) described an inlier of a correlate of the Rocky Cape region Precambrian rocks. At the southern faulted margin of the inlier large blocks of the continental Precambrian sequence are enclosed syndepositionally within an unfossiliferous lithicwacke/basalt trough sequence, indicating that the boundary fault was active during deposition within the Dundas trough. Clearly, whatever the geochemical associations of the basalt may be, they have to be reconciled with known field relationships and environments of their accumulation.

ULTRAMAFIC OCCURRENCES

Later in the evolution of the Dundas trough, ultramafic masses were structurally emplaced during a general deformation. There seems to be no evidence to suggest the mobility needed for them to have originated outside the trough in which they occur, for no units older or younger than the bodies appear to be exotic to the basins in which they are found, and no accompanying unit is diagnostic of a locality elsewhere. Fragments of the fault-bounded ultramafic complexes have been recovered from the basal beds of the Dundas Group, near Dundas [370368]. A period of tectonic emplacements of the ultramafic masses, followed by their exposure and erosion with the contribution of detritus to the overlying Middle Cambrian sediment, is therefore indicated (Rubenach, 1974).

LATE CAMBRIAN DEFORMATION

Apart from large faults such as the Henty [380365], which may have been active during volcanism (Corbett and Lees, 1987), Cambrian deformation is more obviously indicated by the common occurrence of angular unconformities between the basal Owen Conglomerate siliciclastic unit of the Late Cambrian-Devonian Wurawina Supergroup and the underlying Cambrian units. At the northern margin of the Tyennan region the greatest noted differences in the bedding attitude across an angular unconformity at the base of the Wurawina Supergroup is from about 20° at Deloraine [472402; Pike, 1973] to some 50° at Cethana [431407; Jennings, 1963]. In the Fossey Mountain and

Dial Range areas the Wurawina Supergroup extends from the northern margin of the Tyennan region to the north-west, transgressing older units with small inferred differences in bedding dip (<15⁰-20⁰; Burns, 196 the Precambrian rocks of the Rocky Cape region. These unconformities have been equated with movements of the Tyennan and Forth regions acting in continuity (Williams, 1976).

Near the eastern margin of the Dundas trough against the Tyennan region, east of Queenstown, reverse movement along the Great Lyell Fault resulted in uplift of the Cambrian volcanic rocks and caused folds in lower members of the Owen Conglomerate during their accumulation at Pioneer Ridge [383344; Reid, 1976]. The upper beds of the Owen Conglomerate, the Pioneer Beds, rest with angular unconformity - the Haulage Unconformity - on lower members, which were coherent but soft enough for pebbles of the overlying beds to be pressed into them. The movement zone coincides with a marked westward thinning of the Owen Conglomerate. Folding in the lower members is restricted to the eastern margin of the fault, for some 100 m further east, the Pioneer Beds are conformable with the lower members. The deformation is also restricted along the fault length for some two kilometres south of Pioneer Ridge the Haulage Unconformity is represented adjacent to the east side of the fault by a maximum 15⁰ difference between the underlying members and the Pioneer Beds.

On the western side of the Lyell Fault System the hydrothermally altered Cambrian volcanic rocks are known as the Lyell Schists, and the entire micro-structural fabric of these schists can be shown to be related not to Cambrian deformation but to a later deformation (Wade and Solomon, 1958; Cox, 1979), as at Pioneer Ridge where the Pioneer Beds is followed conformably by the younger members of the Wurawina Supergroup, which were folded during the Devonian. The structural surfaces making up the schistosity of the Lyell Schists were synchronously developed, and define a cleavage system parallel to the axial surface of the Devonian fold of Pioneer Ridge, which not only folded the Haulage Unconformity but also the faults of the Lyell Fault System (fig. 1).

STRUCTURES OF UNPROVEN AGE AND DEVONIAN DEFORMATION

Structures of unproven age occur within the Dundas trough. These include the Rosebery thrust and the fault-bounded slices of trough rock units to the west [377375]. These fault slices and their general position with respect to the Mt Read Volcanic Belt have been referred to a possible association with an accretionary prism of an east-dipping subduction zone developed during Cambrian times (Corbett and Lees, 1987).

In an accretionary prism numerous strike-parallel, fault-bounded tracts predominantly face internally in one direction but become sequentially (or stratigraphically) younger in the opposite and oceanward direction. These characteristics, together with the seismic profiles of modern accretionary fore-arcs, indicate that sediments can be underthrust, essentially undeformed, below the prism where it can be underplated or subducted (fig. 2; Leggett, 1987).

It is instructive to note the consistency of the directions of facing within the fault-bounded units and the direction of sequential younging between the units (fig. 2) (although a consistent structural system in itself does not prove subduction for it can be developed in basins of many structural environments). This structural stacking of units is regarded as typical and characteristic of structures associated with an accretionary

prism. If the structures are compared with those present in the Rosebery region (Corbett and Lees, 1987; fig. 2 and 5) it can be seen that the structures of the Rosebery region do not resemble those that would be expected to be associated with the development of an accretionary prism of an east-dipping subduction zone during Cambrian times. It can be concluded that no accretionary prism is present in the Dundas trough.

The Devonian deformation in western Tasmania is expressed by two main phases, which have resulted in interfering folds. The pre-Devonian deformation distribution of the Early Palaeozoic rocks was determined some years ago (fig. 3; Williams, 1983) by unstraining the most competent units of the Wurawina Supergroup (Owen Conglomerate or similarly competent horizon). In recent years much more information has become available for south and south-west Tasmania so that the reconstructed distribution of the Early Palaeozoic rocks would be unreliable in those regions. Elsewhere in Tasmania, however, reconstructions are reliable, and it is interesting to note in Figure 3 the degree of unstraining of Devonian structures (i.e. involving Wurawina Supergroup beds) which is indicated by the distortion of a grid of originally 20 km squares. Visual assessments indicate that the region receiving greatest shortening during Devonian deformation, which is required in order to fit the surrounding proved regional Devonian strains as given within the Wurawina rocks present, is in the Rosebery region, where no Wurawina Supergroup rocks have been preserved. In the Rosebery region, as a result of Devonian deformation, the Cambrian rocks would be expected to show such structures as those occurring (Corbett and Lees, 1987), but are of unknown age.

RIFT DEVELOPMENT

The distribution of remnants of Rocky Cape region rock types is considered to be a valid indication of the existence of a pre-trough Precambrian boundary, as no other reasonable explanation has been given. The Dundas and Dial Range troughs appear to have developed on the site of the older Precambrian boundary, and it is of interest to note how much early rifting is reasonably acceptable before later closure, thereby determining if extension could have been great enough to allow later subduction to develop and be of consequence. The geometrical constraints on opening and closing are given by the present-day matching of Precambrian rock types distributed about the troughs - the Burnie Formation in the north and the Oonah Formation in the south (fig. 4).

Suppose subduction developed in the extended basin and was associated with the generation of the Mt Read Volcanics; then if closure took place at a rate of some 50 mm per year, the basin would be closed in one million years if the original width was 50 km and one margin of the basin was attached to the subducting plate (fig. 4). For a more realistic period of time for the accumulation of the volcanic rocks (ten million years or greater), then the extended basin width would be 500 km or greater. The Rocky Cape region would have to return to the Tyennan and Forth regions within much less than 80° of the starting position for the Burnie and Oonah Formations of the Rocky Cape region to correspond with their inliers across the troughs (fig. 4). This remarkable correspondence of opening and closing paths required by the present-day rock type distribution for rifts to be 500 km or greater does not seem acceptable in such a tectonic regime. It therefore appears that no subduction zone associated with the generation of the Mt Read Volcanics developed within the Dundas and Dial Range troughs.

CAMBRIAN TECTONIC EVOLUTION IN WESTERN TASMANIA

In the southern uplands of Scotland the suture representing a subduction zone was traced in a deep seismic reflection profile and found to be dipping at about 30° and continued to a depth of 12 km to near the MOHO (Brewer et al., 1983). A magnetotelluric survey allowed the suture to be

defined as a zone a few kilometres wide of very highly conductive rocks thought to be of mylonite (Beamish and Smyth, 1986). It seems conceivable that the very high conductivity zones discovered through magnetotelluric studies under the Late Carboniferous and younger rocks at the site of the postulated Tamar Fracture System, and dipping or tapering west (Parkinson and Hermanto, 1986), may be a fossil subduction zone represented by a mylonite sheet. This is a site of subduction suggested recently by P. A. Roberts (Department of Mines lecture, January, 1988). The Tamar Fracture System was postulated as the boundary between two geologically dissimilar regions (Williams, 1976). It is possible that the System developed along a crustal anisotropy truncating a Cambrian subduction zone which was the driving mechanism for development of the Dundas and Dial Range troughs at a Precambrian crustal anisotropy to the west, and for the eventual closure of the Eocambrian-Cambrian troughs.

REFERENCES

BEAMISH, D.; SMYTHE, D. K. 1986. Geophysical images of the deep crust: the Iapetus suture. *J. geol. Soc. London* 143:489-97.

BREWER, J. A.; MATTHEWS, D. H.; WARNER, M. R.; HALL, J.; SMYTHE, D. K.; WHITTINGTON, R. J. 1983. BIRPS deep seismic reflection studies of the British Caledonides. *Nature* 305:206-10.

BROWN, A. V. 1980. Early deposits in a Lower Palaeozoic trough of western Tasmania. *Programmes and Abstracts 4th Australian Geological Convention, Hobart, January 1980.* 23.

BURNS, K. L. 1965. One mile geological map series. K/55-6-29. Devonport. *Explan. Rep. geol. Surv. Tasm.*

COLLINS, P. L. F.; WILLIAMS, E. 1986. Metallogeny and tectonic development of the Tasman Fold Belt System in Tasmania. *Ore Geology Reviews* 1:153-201.

CORBETT, K. D.; LEES, T. C. 1987. Stratigraphic and structural relationships and evidence for Cambrian deformation at the western margin of the Mt Read Volcanics, Tasmania. *Aust. J. Earth Sciences* 34:45-68.

COX, S. F. 1979. *Deformation of the Mt Read Volcanics and associated sulphide deposits, Mt Lyell.* Ph.D. thesis, Monash University.

GROVES, D. I. 1971. The regional significance of the Don Hill fault zone at Mt Bischoff, Tasmania. *Tech. Rep. Dep. Mines Tasm.* 14:7-15.

JENNINGS, I. B. 1963. One mile geological map series. K/55-6-45. Middlesex. *Explan. Rep. geol. Surv. Tasm.*

LEAMAN, D. E. 1986. *Mount Read Volcanics Project : Gravity interpretation west and north-west Tasmania.* Department of Mines, Tasmania.

LEGGETT, J. K. 1987. The Southern Uplands as an accretionary prism: the importance of analogues in reconstructing palaeogeography. *J. geol. Soc. London* 144:737-752.

PARKINSON, W. D.; HERMANTO, R. 1986. The Tamar conductivity anomaly. *Explor. Geophys.* 17:34-35.

PIKE, G. P. 1973. Geological atlas one mile series. Zone 7 Sheet 46 (8214N). Quamby. *Explan. Rep. geol. Surv. Tasm.*

REID, K. O. 1975. Mt Lyell copper deposits, in: KNIGHT, C. L. (Ed.), Economic geology of Australia and Papua New Guinea. *Monogr. Ser. Austr. Inst. Min. Metall.* 5:604-619.

RUBENACH, M. 1974. The origin and emplacement of the Serpentine Hill complex, western Tasmania. *J. geol. Soc. Aust.* 21:91-106.

TURNER, N. J. 1988. The Precambrian inliers and their possible relationships, in: TURNER, N. J. (ed.). The geology and evolution of the latest Precambrian to Cambrian rocks in the Western Tasmania Terrane. *Symposium Abstracts geol. Soc. Aust. Tasm. Div.* 6.

WADE, M. L.; SOLOMON, M. 1958. Geology of the Mt Lyell Mines, Tasmania. *Econ. Geol.* 53:367-416.

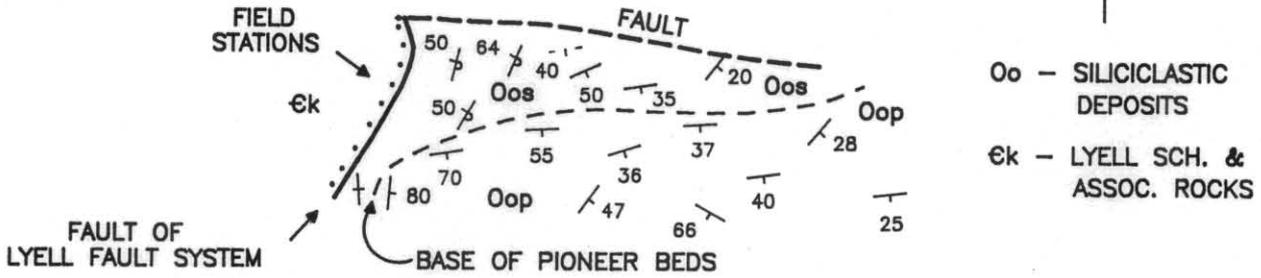
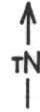
WILLIAMS, E. 1976. *Tasman Fold Belt System in Tasmania. Explanatory notes for the 1:500 000 structural map of pre-Carboniferous rocks of Tasmania.* Department of Mines, Tasmania.

WILLIAMS, E. 1983. The areal distribution of rock-units during Early Palaeozoic times in Tasmania. *Unpubl. Rep. Dep. Mines Tasm.* 1983/61.

[12 May 1988]

PIONEER RIDGE

250m



Oo - SILICICLASTIC DEPOSITS
 €k - LYELL SCH. & ASSOC. ROCKS

CLEAVAGE READINGS FROM STATIONS IN VOLCANICS AT REGULAR INTERVALS ADJACENT TO FAULT OF LYELL F.S.

CONTOURS OF CLEAVAGE POLES >40%
 21 PAIRS OF CLEAVAGES

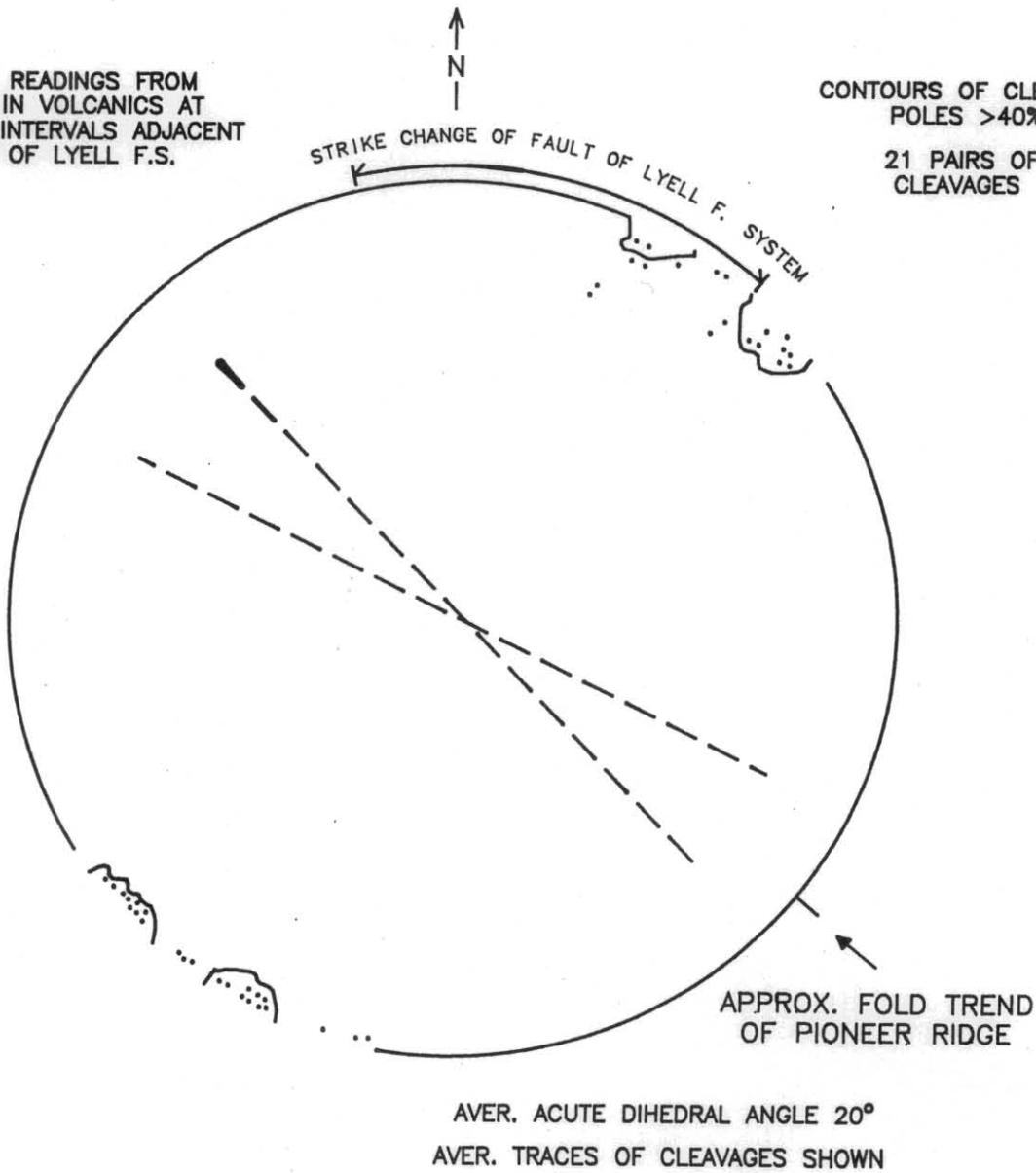


Figure 1. Analysis of structural elements at Pioneer Ridge

5 cm

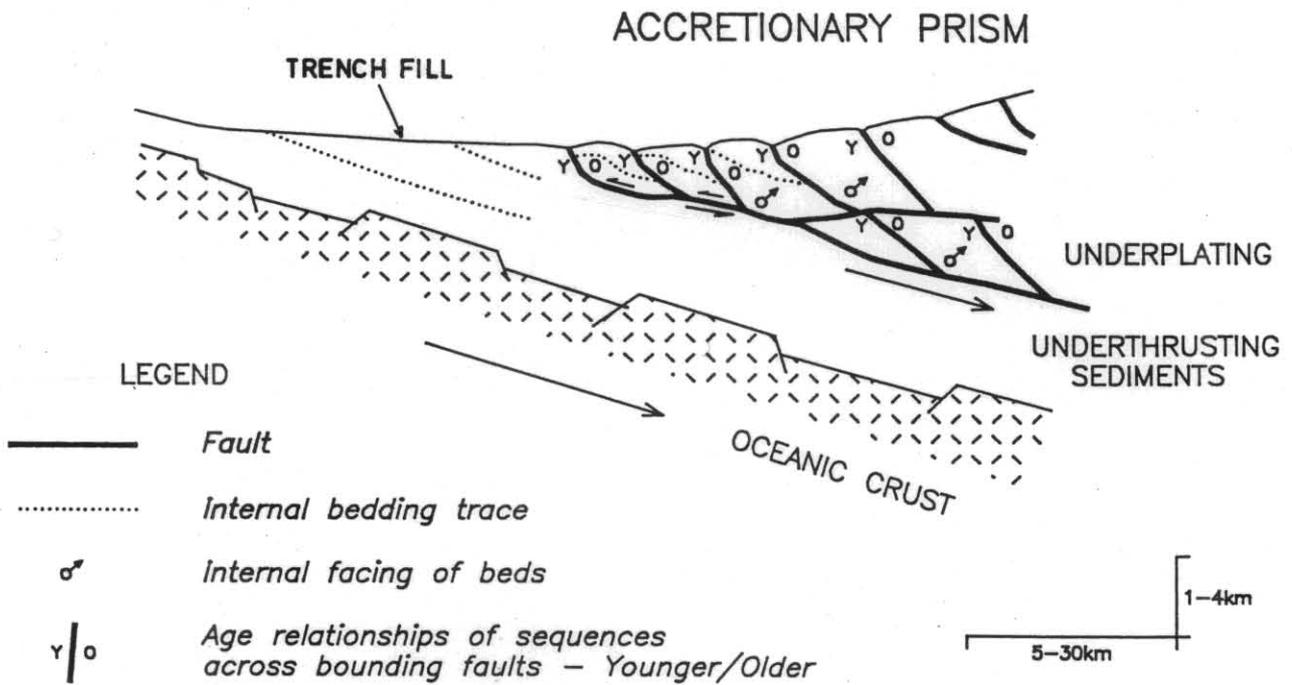


Figure 2. Diagrammatic profile of an accretionary prism (after Legget, 1987).

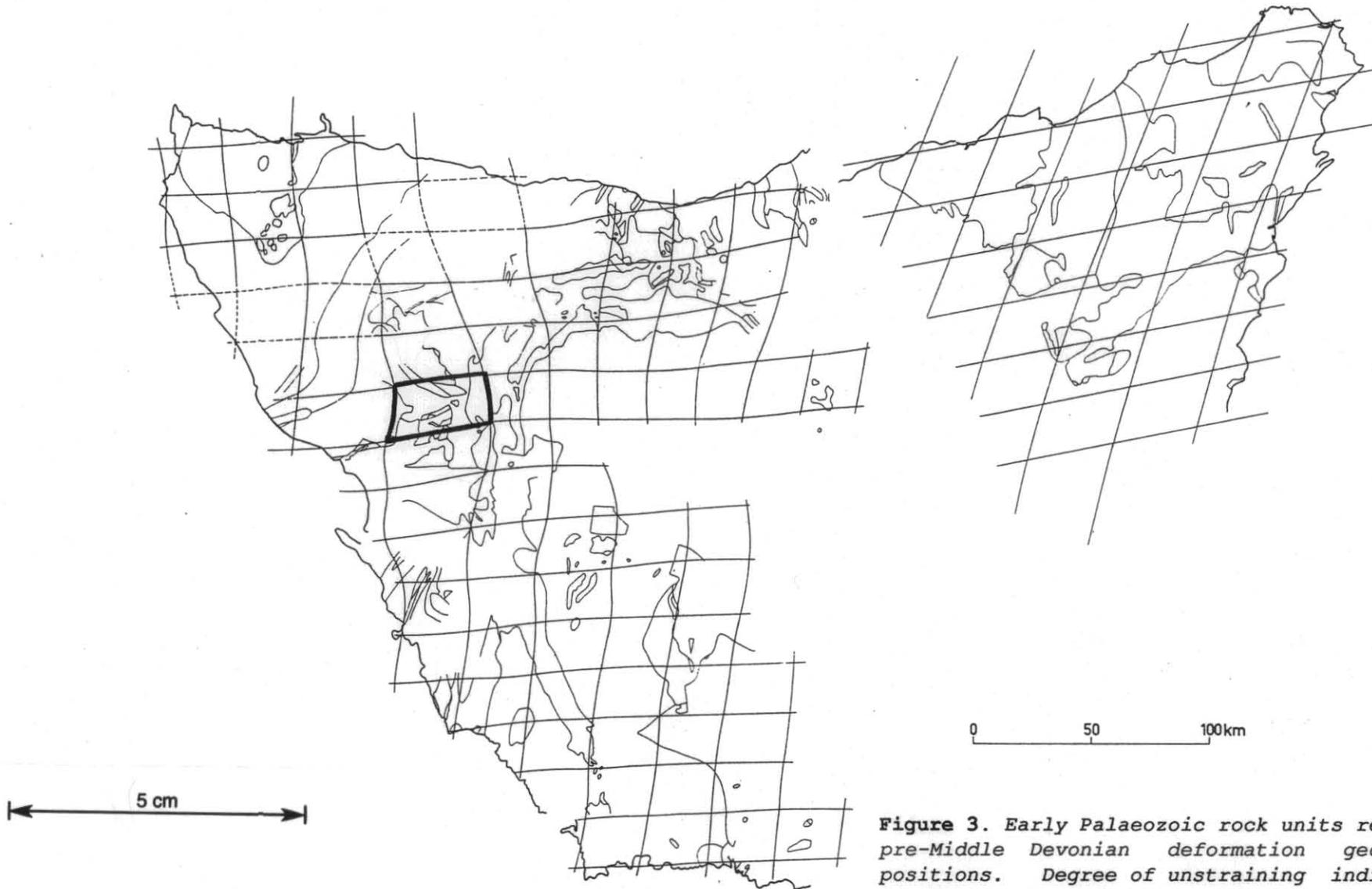


Figure 3. Early Palaeozoic rock units restored to pre-Middle Devonian deformation geographical positions. Degree of unstraining indicated by distortion of grid of originally 20 km squares and boundaries of rock units (cf. Structural Map of pre-Carboniferous Rocks of Tasmania, 1:500 000 scale, 1976, Tasmania Department of Mines). Rosebery region indicated by heavy outline.

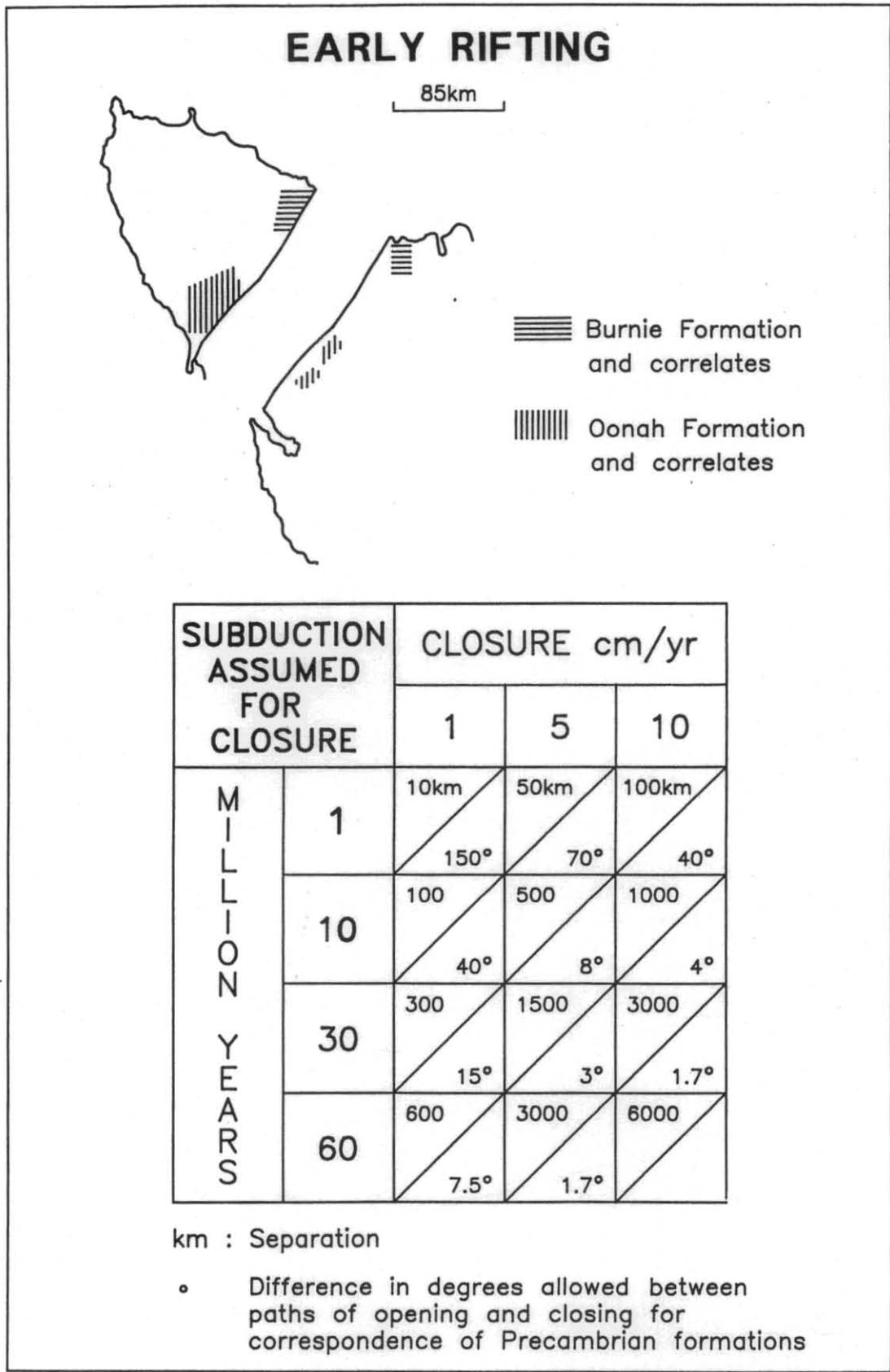


Figure 4. Analysis of opening and closing paths for rifts of various widths.

